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Regional market integration in East Africa: Local but no regional effects?[☆]

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ABSTRACT

We investigate the spatial impact of the establishment of a regional economic community between Kenya, Tanzania, and Uganda in 2001. Measuring economic activity using satellite imagery of lights emanating from Earth at night, we demonstrate that cities near the community's internal borders expanded more than cities further away. The growth effect is temporary and highly localized: only cities less than 90 min of travel from the border experienced an acceleration in growth rates; after four years growth rates revert to their pre-treatment level. We show that this is consistent with an asymmetric reduction in trade costs for two types of trade modalities that co-exist in many parts of sub-Saharan Africa, local small-scale trade and regional large-scale trade, with a larger reduction in costs of the former. Yet, while local effects are relatively large, equivalent to a 5% higher GDP for cities near the EAC's internal borders, region-wide effects are non-significant.

1. Introduction

African and international policy makers regard regional integration as a means to boost economic and human development, with positive effects on a wide range of outcomes such as real income, employment, food security and education (United Nations Development Program, 2011; World Bank, 2012a; World Economic Forum, 2013). Many African countries have therefore embarked, often with significant financial support from donor agencies, on regional trade agreements and liberalisation agendas. Larger markets allow firms to specialise and realise economies of scale, raising the countries' competitiveness also on the world market stage.[1] Firms may respond to increased competition by increasing productivity. African consumers in turn could benefit from a larger variety of goods and services and lower prices. In addition, substantial benefits may come from coordinating investments into public goods, particularly in areas such as transportation, electricity and telecommunication infrastructures (World Bank, 2012b). Yet the extent to which regional integration across sub Saharan Africa may also have distributional consequences over space remains little understood.

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[1] The average African firm is indeed smaller than firms in other world regions. However, market size may not be the most binding constraint for firm growth (Bigsten and Söderbom, 2006; Iacovone et al., 2014).

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In this paper, we investigate the spatial impact of the establishment of the East African Community (EAC) in 2001, which led to the an important reduction in cross-border trade cost between its member states Kenya, Tanzania and Uganda. Using a panel of 180 cities over the period 1992–2013 we apply a difference-in-difference approach using the timing of the EAC and varying treatment intensities across space as our main identification strategy. Measuring urban economies using satellite imagery of lights emanating from Earth at night, we demonstrate that the EAC agreement had an asymmetric impact on city growth. Relative to their pre-EAC trend, cities close to internal EAC borders expanded more quickly than cities further inland. The effects are temporary lasting for only four years, which is consistent with the occurrence of a positive market access shock due to a one-off reduction in cross-border trade costs. We show that the effects remain extremely local, limited only to cities in a 90 min travel distance from the border, with negligible region-wide effects. In line with anecdotal evidence, we argue that our results are consistent with an asymmetric effect of the EAC on two cross-border trade modalities, local small-scale trade and regional large-scale trade, with a strong reduction in trade cost for the former but almost none for the latter. The resulting local effects of the EAC are large. Assuming a nightlights elasticity of GDP as estimated in Hodler and Raschky (2014) for Africa, the increased luminosity is equivalent to a 5% increase in GDP for cities near an internal EAC border.

How trade liberalisation affects countries' economic geography has been the focus of many previous studies. Krugman and Elizondo (1996) were among the first to examine within-country spatial effects of trade openness. In their model, firms' locational choices depend on the interplay between centripetal and centrifugal forces.[2] If cities had identical access to the world market, trade liberalisation would weaken centripetal forces, thus benefiting locations away from a countries' economic core. Yet Alonso-Villar (1999, 2001) later showed that this insight crucially depends on the distribution of economic activity before liberalisation, as trade liberalisation would have a relatively larger impact on cities with better access to the international market. More recent contributions have incorporated these insights into more general quantitative spatial models. These emphasise the role of internal transport costs in shaping the economic geography within-countries in response to external market integration.[3] Fajgelbaum and Redding (2014) built a model that predicts Balassa-Samuelson type of effects over space within countries: external market integration causes a boom in locations with low trade costs to international markets which in turn increases the prices in nontraded sectors in these locations. Similar predictions were attained by Cosar and Fajgelbaum (2016) who developed a model where within-country heterogeneity in access to foreign markets shape how the welfare gains of trade openness are shared across space. These contributions, however, built on relatively stylized spatial set-ups where there is a well connected economic core to international markets, such as a coastal region, and a remote hinterland connected to world markets only through an internal transportation network to the country's economic core. What is not being considered is that a country's remote hinterland will eventually face a border too. Such 'interior' borders may not give access to a world market but to a potential regional market. It is in this latter context that regional trade liberalisation typically plays out across sub-Saharan Africa, as it affects interior borders that divide countries' hinterland regions.

Several studies have shown that interior borders in sub-Saharan Africa are particularly thick (Aker et al., 2014; Brenton et al., 2014; Versailles, 2012). This may hinder the development of border regions in remote hinterland locations because borders limit their regional market access (Allen and Arkolakis, 2014; Redding, 2016). A growing body of literature does indeed confirm the importance of market access in explaining economic activity across space (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003; Donaldson and Hornbeck, 2016; Faber, 2014; Head and Mayer, 2014; Michaels, 2008; Storeygard, 2016). On the one hand, regional integration in sub-Saharan Africa may therefore be particularly beneficial for border regions that are generally less well connected to the countries economic core, as it expands border regions' regional market. On the other hand, the impact of market integration may be more ambiguous, as sub-Saharan African economies share similar factor endowments with large agricultural sectors, which may limit the gains from trade. How regional integration affects spatial economic outcomes in border regions in the context of sub-Saharan Africa remains thus an open question.

Previous empirical work has focused on more advanced economic settings and has found strong responses to changes in cross-border trade costs along border regions. Hanson (1996, 1997, 2005) showed that following trade liberalisation between Mexico and the U.S. in the 1980s and 1990s wages in regions close to either side of the U.S.-Mexican border responded positively relative to wages in regions further away. Brülhart (2011) and Brülhart et al. (2012) show that after the fall of the Iron Curtain in the early 1990s cities at Austria's eastern border experienced stronger growth in employment and wages than cities in the interior. Redding and Sturm (2008) studied a negative shock - the artificial division of Germany after World War Two - and found that cities close to Germany's newly created east-west border suffered relatively larger population losses compared to other cities further away.

We also contribute to a nascent literature on 'informal' cross-border trade (e.g. see the review by Golub, 2015). Ubiquitous in most border regions of sub-Saharan Africa, this type of trade is conducted by small-scale traders who cluster near borders and exploit local customary rules to transport their produce from one country to another.[4] Local cross-border trade often accounts for a substantial share of total trade between African countries. In Kenya, for example, local trade volumes are estimated to be equivalent to formal trade (Gor, 2012). Studies that attempt to identify how small-scale local trade is affected by trade liberalisation policies are rare. A key challenge in identifying the effects of local cross-border trade is that it generally goes unrecorded (World Bank, 2011) and representative surveys of traders are hard to come by. If they exist, they are cross-sectional. This complicates identification. Bensassi et al. (2019), for example, rely on variation in trade policy variables across products and destinations. In this paper, we approach local trade from a spatial geography angle using night-lights measuring effects at the city level. While more aggregated, we thereby obtain a panel dimension which facilitates identification. We explicitly regard local small-scale trade as a potential channel through which trade liberalisation affects economic outcomes across space. We demonstrate that the temporary growth effect we find is consistent with an increase in market access for locally traded goods, where the EAC tariff reductions represented an asymmetric shock that arguably affected the two local small-scale and regional large-scale trade differently. We therefore emphasise the importance of duality in trade modalities that are prevalent in border regions of developing countries.

[2] Centripetal forces stem from economies of scale stemming from better access to consumers and to firms that produce key inputs. Centrifugal forces result from cities having to transport large amounts of agricultural produce from the country's rural areas (Krugman, 1991; Krugman and Venables, 1995) and from congestion, urban wages and land rents, and increased competition (Helpman, 1998).

[3] For literature reviews see Brülhart (2011) and Redding and Rossi-Hansberg (2017).

[4] These local traders are not smugglers, as they do comply with local rules, do operate across official border posts and do pay customs duties. Throughout this article, we therefore refrain from the term 'informal' cross-border trade which is often conflated with the notion of smuggling or illegal trade and use *local* cross-border trade instead.

The reminder of the paper is organized as follows. Section 2 describes the historical background of the EAC. Section 3 presents the data. The estimation strategy is discussed in section 4, followed by the main results and robustness checks in section 5. Section 6 corroborates findings using firm level data. Section 7 ends with a summary.

2. Background

Kenya, Tanzania and Uganda are small, poor and agrarian economies. In 2000, their combined population was around 90 million people (Kenya 31 m; Tanzania 34 m; and Uganda 24 m); their GDP/c (PPP) in 2011 dollars was $2,160, $1,490 and $1,060 respectively; with about 80% of the population living in rural areas across the three countries (World Bank, 2015).

In January 2001 Kenya, Tanzania and Uganda entered into a Free Trade Agreement (FTA) marking the beginning of the East African Community (EAC). The agreement was accompanied by an important shift in the countries' respective trade policies. With immediate effect, Kenya, Tanzania, and Uganda started to reciprocally eliminate a range of trade-restrictive measures. On January 31st, 2001, the EAC trade ministers committed to discontinue the use of any discretionary duties. In Kenya this decision triggered a particularly important change in policy with the elimination of all 'suspended' duties (except on petroleum products), which were being applied on a case-by-case basis to protect 'sensitive' products reaching up to 70% of a product's import value (World Trade Organization, 2001).[5] Tanzania reduced the number of product categories liable to 'suspended' duties from 17 to 4 and lowered the maximum rate for this type of tariff from 50% to 20% on all imports originating in the EAC (International Monetary Fund, 2002, 2003; McIntyre, 2005). In early 2001, Tanzania also eliminated all minimum duty values (MDV), i.e. duty rates that are set in order to reach a minimum price (International Monetary Fund, 2002, 2003). Uganda for its part did not apply any 'suspended' duties before the EAC but applied a discriminatory excise tax of 10% on the importation of several products. This charge was eliminated for a range of manufacturing products in March 2001 (Government of Uganda, 2001).

These changes were very significant. Although Kenya, Uganda, and Tanzania had been granting each other preferential market access at MFN tariff discounts of 60%–90% since the 1980s, discretionary tariff measures - such as suspended duties - were being levied on top of preferential MFN rates.[6] For a wide range of products traded in the region, pre-EAC discretionary duties would therefore often amount to over 90% of the overall tariff burden. After applying the preferential market access discounts, maximum rates amounted to only 4% in Kenya, 5% in Tanzania and 6% in Uganda.[7] With discretionary duties of up to 70%, 50% and 10% of the import value in Kenya, Tanzania and Uganda respectively, these amounted for a much larger share of the overall tariff burden than the MFN tariffs.

A large share of cross-border trade takes place locally, involving small-scale traders who cluster in border regions and seek to sell their produce in nearby markets across the border (World Bank, 2012b; World Bank and World Trade Organization, 2015). For 1995, for example, it was estimated that 11% and 31% of Tanzania's trade with Kenya and Uganda was local, respectively (Ackello-Ogutu and Echessah, 1998). In Uganda as much as 20% of total trade with Kenya and Tanzania has been estimated to occur in this way between 2005 and 2013 (Bank of Uganda, 2017). Importantly, many of these local traders are not smugglers, as they do comply with local rules, do operate across official border posts, and do pay customs duties (Uganda Bureau of Statistics, 2009; Titeca and Kimanuka, 2012; Uganda Bureau of Statistics, 2014). In a 2007 survey of 350 local traders undertaken in Uganda, the payment of taxes and customs duties was stated as the most important constraint for this type of trade (Uganda Bureau of Statistics, 2009). Two other features set this type of trade apart from more formal forms of trade. First, it is inherently small-scale implying that local traders cluster near border regions as per-unit transport costs become prohibitive over longer distances. Second, local cross-border trade is much less affected by non-tariff barriers (e.g. quality standards, customs procedures, rules of origin regulations, etc.) that apply to formal trade and typically persist under an FTA. The establishment of the EAC may thus have stimulated local economic activity in border regions but failed to leave a significant imprint on economic activity at the regional level.

To investigate this, we treat commencement of the EAC-FTA in 2001 as a trade shock that affected economic activities across space.[8] We did not find any indication that there were other contemporary events which could have affected the year in which the EAC was finally launched. All countries had experienced relative economic and political stability since the beginning of the 1990s and discussions at the top political level on the possible re-establishment of the EAC had started as early as 1993.[9] Hence, we assume that the EAC-FTA was exogenous to events in the three member countries. The same cannot be said for the EAC's expansion in 2007 when Burundi and Rwanda became formal members of the trade bloc. It was only after the end of the Burundian civil conflict and the return of political stability to Rwanda in the early to mid-2000s that formal negotiations on their accession to the EAC commenced. For this reason, our study only focuses on Kenya, Tanzania, and Uganda.

We also test for effects that occurred with the establishment of a Customs Union (CU) in 2005 and a Common Market (CM) in 2010, two further milestones of the EAC integration process. However, in neither of these cases, do we expect effects to be particularly large, as the effective changes in intra-regional tariff protection levels were comparatively small.[10]

[5] In the EAC the term 'suspended' duties are used to refer to discretionary duties which can be adopted by ministerial decree on a case-by-case basis. They are levied on the CIF value of an imported product in addition to the applicable MFN tariff rate. In 2001, 'sensitive' items represented 16.1%, 25.9% and 30.0% of total imports for Kenya, Uganda, and Tanzania, respectively (McIntyre, 2005).

[6] Preferential access was being granted under the Common Market for Eastern and Southern Africa (COMESA). Tanzania left COMESA in 2000 but maintained the preferential treatment of Ugandan and Kenyan imports.

[7] Pre-EAC, the top MFN tariff band (excluding discretionary tariffs) stood at 40% in Kenya, 25% in Tanzania, and 15% in Uganda.

[8] Given that the EAC agreement was signed in November 1999 and ratified in June 2000 by the countries' respective parliaments, we also considered 2000 as our watershed year. Yet, Kenya introduced a range of suspended duties on several products as well as hiking import duties on agricultural products as late as in 2000 (International Monetary Fund, 2002). Due to budgetary constraints, Tanzania also decided to refrain from further duty reductions in the 2000/01 budget and did not change its policy regarding the use of discretionary duties such as MDV and 'suspended' duties until mid2001 (Government of Tanzania, 2000). It is thus apparent that the EAC agreement was not translated into policy until it was launched in early 2001. The first EAC council meeting between EAC trade ministers took place in 2001.

[9] The first post-independence attempt to transform the region into a single economic entity took place between 1967 and 1977. Hazlewood (1979) analyses which factors lead to the EAC's early disintegration.

[10] The establishment of the CU resulted in the adoption of a common external tariff and a complete removal of remaining tariffs on regional trade with the exception of Kenyan exports to Tanzania and Uganda, for which tariffs were to be removed gradually until the establishment of the Common Market by 2010. Yet because these countries had already been granting each other preferential tariff treatment before the Customs Union came into force, the effective changes in intra-regional tariff protection levels were small relative to the pre-CU average tariffs of 1.9%, 3.4% and 5.8% in Kenya, Tanzania, and Uganda respectively (Stahl, 2005).

3. Data

Our unit of observation are urban agglomerations that we call cities. We measure economic activity by the amount of light emanating from Earth at night and recorded by weather satellites every night between 8:30pm and 10:00pm (NOAA National Geophysical Data Center, 2016). Light intensity is measured at 30 arc-second resolution (equivalent to 0.86 km^2 at the equator), on a scale from 0 to 63. Henderson et al. (2011, 2012) showed that changes in the amount of light are a powerful proxy for GDP growth, particularly when used to infer long-run growth and when disaggregate data of traditional national account based measures are lacking or unreliable. Both of these conditions are present in our study.

Following Henderson et al. (2017), we define a city and its boundaries as the contiguous lit area in any year between 1992 and 2013 (i.e. this is the outer envelope of lights after overlaying the stable nightlights images for each year).[11] We then retrieve the sum of nightlights within a city's boundary for each year. We define the city centre as the on average most intensely lit grid cell within a city's boundary. To establish the population of each city, we draw data from the three most recent censuses in each country (1989, 1999 and 2009 for Kenya; 1988, 2002 and 2012 for Tanzania; 1991, 2002 and 2014 for Uganda). For years falling between the census years, we interpolate population figures. Overall, we have a panel of 180 cities in Kenya, Tanzania and Uganda over the period 1992–2013.

We then measure the distance to the EAC internal border by travel time. We connect each city centre to East Africa's road network, which we establish using a Michelin road map of the region. We used a map of 1991 to abstract from endogeneity problems. Following Michelin's road classification we distinguish between three types of roads: tarmac roads, improved roads, and earth roads. In addition, we identify the location of the EAC's official internal border crossings (East African Community Secretariat, 2015).[12] Using road-type specific travel speeds for sub-Saharan Africa from Dorosh et al. (2010) we calculate the shortest travel time between cities and the EAC's internal border crossings.[13] We do not consider other forms of transport such as rail and water, as they only play a marginal role in the region's transport network.

We define border regions as any location that falls within 90 min travel time to any official EAC internal border crossing. We chose this threshold to ensure that any city falling into the border region is always closer to an EAC border than to the primate city (Kampala and Nairobi are between 3 and 4 h from the closest EAC border). Yet we also relax this definition and test for effects beyond 90 min. Of the 180 cities in our sample, 21 fall into the EAC's border regions.[14] In 1992, all except one of these 21 cities near the EAC's internal borders had a population of less than 100,000. This continued to be the case in 2013. Fig. 1 shows the 1992 road network and the spatial distribution of cities. Table 1 provides summary statistics by country and city location.

In addition, we account for the cities' market access by constructing two population-based market access indicators.[15] First, we calculate a measure for each city i's access to the domestic market, which we define as $DMA_i = \sum_{d \neq i}^{D} POP_d / e^{\sigma \times travel_{id}}$, where D is the total number of domestic cities accessible within the country of city i, POP_d is population of city d and $travel_{id}$ is the network distance between city i and city d (in hours of travel) via the road network of 1991. Second, we establish a measure for each city i's access to the regional market, when assuming frictionless movement across borders. We therefore refer to this measure as city i's regional market *potential*. We calculate it as $RMP_i = \sum_{f}^{F} POP_f / e^{\sigma \times travel_{if}}$, where F is the total number of foreign cities f outside the country of city i, POP_f is population of city f and $travel_{if}$ is the network distance between city i and foreign city f (in hours of travel) via the road network of 1991. For both measures σ is the distance decay parameter. Several structural gravity models show that σ is implicitly defined by $\sigma = \kappa \times \phi$, where κ stands for the trade elasticity measuring the responsiveness of trade to an increase in trade costs (Anderson and van Wincoop, 2003, 2004; Eaton and Kortum, 2002). From the literature we take $\kappa = 8.4$.[16] In our case ϕ represents the average per unit cost of transporting a good for one hour over the East African road network relative to the good's overall value; i.e. $e^{\phi \times travel_{ij}} - 1$ represents the average ad-valorem tariff equivalent of long distance overland transport for a good between city i and city j. Using monthly petrol prices for seven Ugandan cities between 2005 and 2015 we find $\phi = 0.005$. Hence, $\sigma = 0.042$.[17]

The EAC covers different agro-climatic zones. To account for these differences, we use rainfall data from TAMSAT (Tarnavsky et al., 2014).[18] Specifically, we calculate annual and average rainfall between 1992 and 2013 for each 0.5 grid cell in which the cities fall.

We validate the use of nightlights as a proxy of economic activity and shed some light on the sector composition before and after the establishment. We use the World Electric Power Plants Database (WEPP) to investigate electricity production *capacity* within the urban agglomerations for each year (S&P Global Platts, 2016). The database lists power plants, the city in which they are located, the capacity (in megawatts electric) and the year when the plant entered production (N Kenya: 425, Uganda: 135, Tanzania: 439 at 243 locations). Entries are based on business news reports, web information followed by written and telephone inquiries. We also use data from the 2002 Uganda Business Register (UBR) which recorded all Ugandan businesses with a physical establishment across all towns and trading centres. A key characteristic of this data is that it also includes micro-enterprises which are typically 'informal' type of businesses. This very rich set of information is only available for Uganda.

4. Empirical strategy

We estimate the spatial effects of the EAC in a difference-in-difference framework using the timing of the EAC and varying treatment intensities across space as our main identification strategy. We proceed in steps. We first establish the spatial effects of the EAC by comparing the growth rates of cities near an internal EAC border with those of cities located further away. We then examine whether the spatial pattern of post-EAC growth rates is better explained by the occurrence of local as opposed to region-wide effects. Finally, we implement a range of robustness test to validate our results against several identification concerns.

[11] Web Appendix 1 provides a more detailed account of data sources and construction.

[12] The set of border crossings does not change over time.

[13] The average travel speeds are: 50 km/h for tarmac roads, 35 km/h for improved roads, and 25 km/h for earth roads.

[14] Web Appendix 2 Table A1 lists the name and population of each of the 21 cities.

[15] The use of population-based market access indicators to measure the number and size of markets available at low trade cost can be traced back to Harris (1954). More recent studies have shown that population-based market access indicators are a good proxy for more model dependent market access measures derived from formal structural gravity trade models (Donaldson and Hornbeck, 2016; Eaton and Kortum, 2002).

[16] The preferred estimate for κ in Eaton and Kortum (2002) is 8.28; Donaldson and Hornbeck (2016) estimate a value of $\kappa = 8.22$; Caliendo and Parro (2015) find $\kappa = 8.64$ across 20 industries.

[17] Web Appendix 3 provides a more detailed account of how trade costs are estimated.

[18] TAMSAT data is available at https://www.tamsat.org.uk.

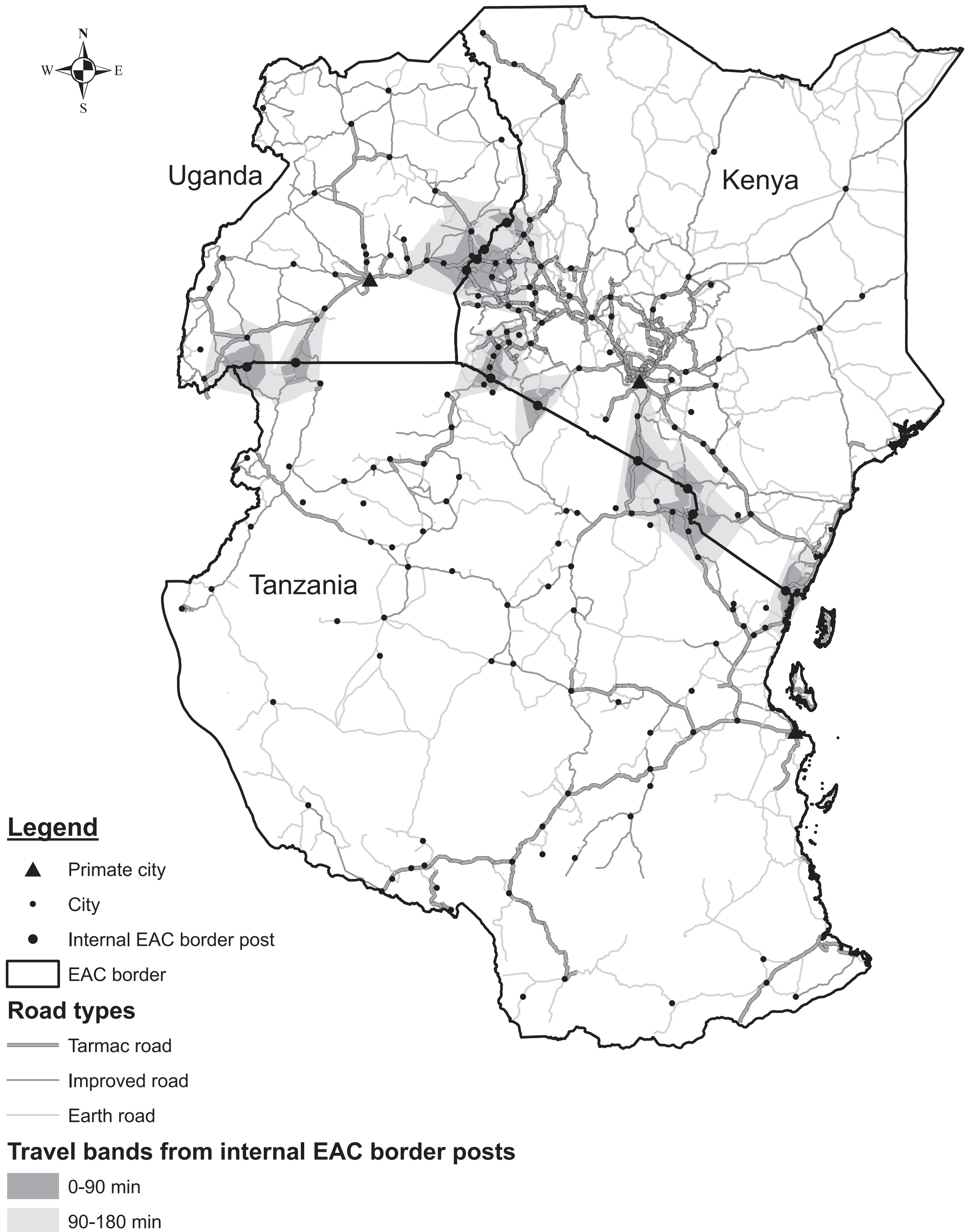

Fig. 1. The East African road network and location of cities in the EAC.

4.1. The identification of spatial effects

Our main hypothesis is that the establishment of the EAC caused a trade shock that was larger for cities near an internal EAC border than similar cities further away. In line with previous empirical research on the spatial impact of trade shocks (Redding and Sturm, 2008; Brülhart et al., 2012), we investigate this hypothesis by examining cities' growth response to the establishment of the EAC across space. We distinguish between the three phases of the EAC to date, i.e. (i) the years following the free trade agreement (FTA) from 2001 to 2004, (ii) the post Customs Union (CU) years from 2005 to 2009, (iii) and the years following the adoption of a common market (CM) in 2010. The FTA represented a much larger trade shock than the CU or CM. Hence, we expects strongest effects in the years following the FTA in 2001. Our baseline specification takes the following form:

$$\begin{aligned}\triangle logNL_{it} &= \alpha_0 + \beta Border_i + \gamma_1(Border_i \times EAC_{FTA}) \\ &\quad + \gamma_2(Border_i \times EAC_{CU}) + \gamma_3(Border_i \times EAC_{CM}) \\ &\quad + X_{it}'\delta + \theta_{ct} + \varepsilon_{it} \qquad (1)\end{aligned}$$

Table 1
Summary statistics.

Variable	Statistic	Kenya		Tanzania		Uganda	
		Border Region	Other Regions	Border Region	Other Regions	Border Region	Other Regions
Cities	n	10	53	7	81	4	25
1992 Nightlights	mean	513	2,533	1,450	904	556	1,173
	sd	298	9,471	2,310	2,346	427	3,648
1992 Population	mean	21,960	74,322	22,530	48,526	28,825	59,911
	sd	17,113	301,782	38,304	164,546	21,052	177,069
1992 DMA (in thousands)	mean	2,872	2,865	1,914	1,925	1,046	1,214
	sd	51	523	346	413	55	200
1992 RMP (in thousands)	mean	2,729	2,469	3,690	2,250	4,196	3,279
	sd	93	412	192	733	86	468
Traveltime to nearest EAC border post (hrs)	mean	0.75	6.36	0.54	12.94	0.61	5.28
	sd	0.57	5.57	0.50	8.09	0.53	3.17
Traveltime to primate city (hrs)	mean	8.43	7.20	19.00	17.60	4.11	4.81
	sd	0.49	5.23	8.17	9.13	0.85	3.64
Average annual rainfall (mm)	mean	1,322	829	906	923	1,293	1,036
	sd	240	399	260	168	127	180

Note: The border region is defined as locations within 90 min of an internal EAC border crossing; population estimates are based on census data.

where $\triangle logNL_{it}$ is the change in log nightlights NL of city i between year t and $t-1$.[19] $Border_i$ is a dummy variable equal to one, if city i is located within 90 min of travel from an internal EAC border point. EAC_{FTA}, EAC_{CU} and EAC_{CM} are dummy variables equal to one for the years 2001-2004, 2005-2009, and 2010-2013 (i.e. the years following the start of the EAC-FTA, EAC-CU and EAC-CM, respectively). $X_{i,t}$ is a vector of control variables to account for the following time-invariant and time-varying city characteristics: (i) city i's travel distance to the primate city, log domestic market access $logDMA_i$ and log population, all measured in 1992, average annual rainfall over the 1992–2013 period, and (ii) year-on-year changes in rainfall levels. We include country-year fixed effects θ_{ct} to account for country specific time trends. Controlling flexibly for time is important, because African countries enjoyed a strong expansion in income and nightlights in the 2000s in general.[20] Identification then comes from changes across space within countries. ε_{it} is the error term. All our standard errors are adjusted for clustering at the city level.

Specification (1) allows us to examine whether the EAC integration process induced a change in the growth performance of cities near an internal EAC border (our treatment group) relative to cities further away from the border (our control group). Our main coefficient of interest is γ_1, which test the spatial growth response to the EAC-FTA in cities near the border due to their relative proximity to the EAC market. Cross-border trade costs fell strongest with the establishment of the EAC-FTA and to a much smaller extent following the EAC-CU and EAC-CM. Hence we expect γ_1 to be larger than γ_2 and γ_3. β accounts for any systematic differences in the growth rates between border and control cities in the pre-EAC era between 1993 and 2000. In our case, we would expect β to be negative for the following reasons. First, the border cut cities off parts of their 'natural hinterland' that is located across the border. Second, border regions may for historical reasons be disadvantaged, as infrastructure investments early in the development process led manufacturing exploit urban scale economies in relatively few locations at the economic core; concentration is then reinforced by structural transformation (Henderson et al., 2018).[21] Third, government policies may favor the economic core in the provision of public goods.

First-differencing nightlights addresses time-invariant unobservables that affect the level of nightlights. However, there may be unobservables affecting the change in nightlights. Hence, we also estimate Eq. (1) with city fixed effects. Including city fixed effects, however, does not permit the estimation of β - nightlights growth before the EAC. This compromises our ability to interpret the results in terms of the EAC's impact on the overall distribution of economic activities. We therefore rely on the estimation without city fixed effects for the interpretation of most of our results, and validate them against a specification with city fixed effects to ensure that results are not driven by any city-specific unobservables affecting the change in log nightlights.

We then augment specification (1) to test whether heterogeneities in the treatment effect γ_1 are consistent with an increase in market access. First, we investigate how the treatment effect varies as one moves away from the border. For this purpose, we create four distance bins of 45 min to the border. If the trade shock does indeed emanate from a reduction in cross-border trade costs, the treatment effect should decline monotonically as one moves away from the border. Second, we examine city size. As argued by Redding and Sturm (2008), a larger home market makes cities less reliant on trade with other cities. We define small, medium, and large towns according to 1992 population tertiles and test whether the size of the treatment effect decreases with city size.[22] Third, we investigate whether varying levels of regional market potential constitute different treatment intensities within the treatment group. For this, we categorise cities with small, medium, and large regional market potential according to 1992 regional market potential (RMP) tertiles.

4.2. The identification of local versus region-wide effects

A reduction of trade costs at the border may affect all cities. Therefore, cities that are included in the control group may potentially be affected by the FTA as well, even if to a smaller extent. Using distance thresholds alone, we cannot discriminate between the occurrence of local and region-wide effects.

[19] Nightlights are positive for all cities and years, so that taking the log does not result in missing values.

[20] The nightlights data is constructed using imagery from satellite F10 for the years 1992–94, F12 for 1995–1997, F14 for 1998–00, F15 for 2001–03, F16 for 2004–09, and F18 2010–13. There may be systematic differences in measuring nightlight emissions across satellites. This also warrants the inclusion of year fixed effects.

[21] Between 1991 and 2000, average agricultural output as a share of GDP amounted to 31% in Kenya, 43% in Tanzania and 45% in Uganda (World Bank, 2015). For the period 2001–2010 these shares had fallen to 26%, 31%, and 26% respectively.

[22] With 21 border cities, 7 are defined as small, 7 as medium and 7 as large.

Table 2
Baseline results - The spatial impact of the EAC on city growth.

Variables	(1)	(2)	(3)
Border	−0.011***	−0.010**	
	(0.004)	(0.004)	
$Border \times EAC_{FTA}$	0.028***	0.028***	0.028***
	(0.009)	(0.009)	(0.009)
$Border \times EAC_{CU}$	0.002	0.002	0.002
	(0.006)	(0.006)	(0.006)
$Border \times EAC_{CM}$	0.007	0.007	0.007
	(0.008)	(0.008)	(0.008)
Market access controls	NO	YES	
Rainfall controls	NO	YES	YES
Country-year FE	YES	YES	YES
City FE	NO	NO	YES
Observations	3,780	3,780	3,780

Notes: Data based on a panel of 180 cities in Kenya, Tanzania, and Uganda from 1992 to 2013. The dependent variable is the annual change in log nightlights. *Border* is a dummy variable taking the value 1 for a city within 1.5 h travel distance of an internal EAC border crossing. EAC_{FTA}, EAC_{CU}, and EAC_{CM} are dummy variables taking value 1 for the post-EAC years 2001–04, 2005–09, and 2010–13 respectively. Market access controls include log population in 1992, log domestic market access (*DMA*) in 1992, and travel time to the primate city (in 10 h). Rainfall controls include average rainfall 1992–2013 as well as yearly changes. Robust standard errors adjusted for clustering at the city level in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% respectively.

To identify local effects and disentangle them from region-wide effects, we define an EAC impact variable that measures city *i*'s foreign market potential relative to its home and domestic market size:

$$\Omega_i = \frac{RMP_{92,i}}{POP_{92,i} + DMA_{92,i} + RMP_{92,i}} \tag{2}$$

Ω_i merges its own market size $POP_{92,i}$, its access to nearby domestic markets $DMA_{92,i}$, and its access to more distant regional markets $RMP_{92,i}$ into one single metric.[23] On the basis of Ω_i, we examine the spatial impact of the EAC more flexibly by including a continuous treatment effect in our difference-in-difference framework that does not rely on distance thresholds. This allows us to test for the presence of region-wide effects that may contaminate the control group. The following regression model synthesizes our approach:

$$\begin{aligned}\triangle logNL_{it} &= \eta(log\Omega_i \times EAC_{FTA}) + \lambda(Border_i \times EAC_{FTA}) \\ &\quad + X'_{it}\delta + v_i + \theta_{ct} + \varepsilon_{it}\end{aligned} \tag{3}$$

where all variables are defined in line with previous specifications. We implement Eq. (3) using city fixed effects v_i and focus on the growth impact in 2001–04 for which we expect the strongest effects. We are interested in the coefficients η and λ. η captures the region-wide effect of the increased market access due to the EAC, regardless of whether cities fall into the 90min distance band from the border or not. λ captures the local effect. Hence, the difference between specification (1) and (3) is that we now test for the presence of local effects by allowing cities to respond to regional effects beyond our border threshold. If $\eta > 0$, we interpret this as suggesting the presence of region-wide effects. On the contrary, if $\eta = 0$ and $\lambda > 0$, this would imply that the EAC did not have region-wide effects and that growth effects were contained locally.

[23] Note that the parameter σ, which defines how trade linkages between cities decay over space due to transport cost affects the size of *RMP* and *DMA* (and thus Ω_i). We set $\sigma = 0.042$ section, which reflects the decay parameter we derived from long distance trade between cities for petrol (see section 3). We show that results are robust to alternative choice of σ.

4.3. Robustness analysis

We validate our results running a number of robustness tests. First, we consider anticipation effects and that trade policies may have unobservedly taken effect in advance of the actual commencement date of the EAC in 2001. We therefore test whether the effects do indeed sharply coincide with the launch of the EAC by adding year-specific leads and lags to the estimation. Second, regional integration agendas may also come along with public infrastructure investments. If this was the case, effects could be wrongly attributed to trade instead of infrastructure. We therefore examine whether investments in electricity plants in the border region took off simultaneously with the EAC-FTA. Third, the FTA may have led to a general increase in trade related traffic, that border crossings were ill-prepared to handle. We address the concern that effects are due to congestion at border crossings by excluding those cities from the estimation. Fourth, we apply a matching strategy to examine alternative choices of the control group. Fifth, we test the sensitivity of our results to the choice of specification using nightlights in levels rather than changes. Sixth, we estimate Conley standard errors, which accommodate error correlation structures over time and space more flexibly.

5. The spatial impact of the East African Community

5.1. Main results

Our baseline estimation results are reported in Table 2. Column 1 provides a parsimoneous estimation of Eq. (1) excluding all control variables except country-year fixed effects, which are important to absorb the general increase in nightlights in the 2000s. Column 2 includes market access and rainfall controls. In column 3 we include city fixed effects. In all three estimations the treatment effect γ_1 is positive and significant. In the first four years after the establishment of the EAC, cities in border regions outgrew cities in interior regions by 2.8 percentage points, relative to their respective pre-EAC growth rates. This indicates that the establishment of the EAC had a strong effect on economic activities in cities near the border. The pre-treatment effect β is negative and remains significant even after controlling for a range of market access variables. This suggests that without regional integration there existed a periphery effect in border regions.

Table 3
Augmented baseline results - Heterogeneity across space and cities.

Variables	(1)	(2)	(3)
$Border_{0-45} \times EAC_{FTA}$	0.040***		
	(0.013)		
$Border_{45-90} \times EAC_{FTA}$	0.021*		
	(0.012)		
$Border_{90-135} \times EAC_{FTA}$	0.010		
	(0.010)		
$Border_{135-180} \times EAC_{FTA}$	0.009		
	(0.009)		
$Border \times EAC_{FTA} \times SmallCity$		0.036***	
		(0.012)	
$Border \times EAC_{FTA} \times MediumCity$		0.028*	
		(0.016)	
$Border \times EAC_{FTA} \times LargeCity$		0.022	
		(0.016)	
$Border \times EAC_{FTA} \times SmallRMP$			0.006
			(0.012)
$Border \times EAC_{FTA} \times MediumRMP$			0.037*
			(0.019)
$Border \times EAC_{FTA} \times LargeRMP$			0.041***
			(0.011)
4 distance bands × 2005–2013	YES	NO	NO
Border × 2005–2013 × city size tertiles	NO	YES	NO
Border × 2005–2013 × RMP tertiles	NO	NO	YES
Rainfall control	YES	YES	YES
Country-year FE	YES	YES	YES
City FE	YES	YES	YES
Observations	3,780	3,780	3,780

Notes: Data based on a panel of 180 cities in Kenya, Tanzania, and Uganda from 1992 to 2013. The dependent variable is the annual change in log nightlights. Small, medium, and large towns are defined according to 1992 population tertiles. Small, medium, and large regional market potential are defined according to 1992 regional market potential (*RMP*) tertiles. All other variables specified in line with previous specifications. Robust standard errors adjusted for clustering at the city level in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% respectively.

The impact coefficients for the post-2004 periods are also positive, but smaller than the initial effects and statistically insignificant. This aligns well with available evidence suggesting that cross-border trade costs declined much less during these latter years. It also suggests that the impact of the initial trade shock of the EAC on city growth was temporary corresponding to a levels rather than a growth effect.

Table 3 presents results of an augmented specification allowing for heterogeneity in the treatment across space, city size and regional market potential. For the sake of simplicity we focus on the early years of the EAC between 2001 and 2004, for which we found strong border effects. We first investigate how the EAC impact varies with distance to the border. To this end, we include four dummy variables representing the distance bands 0–45 min, 45–90 min, 90–135 min and 135–180 min. In column 1, the EAC effect decreases in size the further away a city is located from the border, becoming insignificant beyond 90 min of travel time to the border.

In column 2 of Table 3 we examine whether the impact of the EAC varies with city size. We establish three treatment categories - large, medium and small - depending on whether the city falls into the bottom, medium or top 1992 population tertile among the 21 treatment cities. In line with Redding and Sturm (2008) and Brülhart et al. (2018), we find that, within the treatment group, the EAC had a larger growth impact on the smaller cities close to the border: Small treatment group cities experienced an almost two times larger growth impact than large treatment group cities.

In column 3 of Table 3 we shed further light on how the effect varied with treatment intensity. Specifically, we investigate whether the EAC had a stronger impact on those cities that gained a larger market after the establishment of the regional bloc, by dividing the sample of 21 treatment cities into three tertiles of high, medium, and low regional market potential (*RMP*). The results show that the treatment effect increases with regional market access. With the start of the EAC, treatment cities that had a large and medium regional market potential experienced a 4 percentage points larger annual growth impulse in the first four years of the EAC than treatment cities with a small regional market potential.

5.2. Regional versus local effects

In Table 4 we discriminate between local and regional effects. In column 1 we first test how the EAC impact variable Ω_i defined in Eq. (2) explains cities' growth response in the first four years of the EAC. A larger Ω_i is positively, yet insignificantly associated with a greater growth response to the EAC. Exposure to the regional market does not appear to predict region-wide growth. In line with specification 3, we then account for local effects separately. These results are shown in column 2. The interaction between Ω_i and the EAC-FTA turns negative and continues to be far from significant at any reasonable confidence level. The local effect of the EAC-FTA, however, is positive and highly significant. Moreover, its magnitude is very similar to the treatment effect found in our baseline results.

We draw three lessons from these results. First, the positive coefficient in column 1 appears to be fully driven by the existence of local effects. Second, the previously found local effects do not appear to be contaminated by the occurrence of region-wide effects. Third, the impact of the EAC-FTA appears to have been entirely contained in border regions with no effects farther inland. To confirm this further, we allow the local treatment effect to vary with distance to the border using the same distance bands specified earlier. As shown in column 3, the impact of the EAC-FTA reveals the same spatial

Table 4
The EAC - A local market access shock.

Variables	(1)	(2)	(3)
$\Omega \times EAC_{FTA}$	0.028	−0.027	−0.048
	(0.045)	(0.045)	(0.049)
$Border \times EAC_{FTA}$		0.030***	
		(0.010)	
$Border_{0-45} \times EAC_{FTA}$			0.044***
			(0.014)
$Border_{45-90} \times EAC_{FTA}$			0.024*
			(0.12)
$Border_{90-135} \times EAC_{FTA}$			0.012
			(0.011)
$Border_{135-180} \times EAC_{FTA}$			0.011
			(0.009)
$\Omega \times$ 2005–2013	YES	YES	YES
Border × 2005–2013	NO	YES	NO
4 distance bands × 2005–2013	NO	NO	YES
Rainfall control	YES	YES	YES
Country-year FE	YES	YES	YES
City FE	YES	YES	YES
Observations	3,780	3,780	3,780

Notes: Data based on a panel of 180 cities in Kenya, Tanzania, and Uganda from 1992 to 2013. The dependent variable is the annual change in log nightlights. Ω measures the exposure of each city to the regional market based on a decay parameters of $\sigma = 0.042$. All other variables specified in line with previous specifications. Robust standard errors adjusted for clustering at the city level in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% respectively.

pattern with almost identical coefficients as in our earlier results of Table 3. Finally, we consider whether Ω_i may have been misspecified and test the sensitivity of our results by doubling and halving the decay parameter used to calculate the market access components in Eq. (2). As shown in the Web Appendix Table A2, our interpretation of results remains unchanged. We therefore conclude that the increase in regional market access through the establishment of the EAC had a strong local but very limited region-wide effects.

These findings imply that the impact of the establishment of the EAC was highly localized. Only cities located along a narrow distance band of 90 min from the border were affected by the establishment of the EAC. The fact that effects declined with distance to the border is consistent with an increase in market access that diminishes with transport costs. The strong spatial concentration of the impact, however, raises the question whether it is transport costs alone that can explain the spatial pattern we find.

To illustrate this, we consider the same distance decay function as for our market access measures, $e^{-\sigma \times travel_{if}}$, where $\sigma = \kappa\phi$. As defined κ stands for the trade elasticity and ϕ for ad-valorem transport costs of long distance trade. Basic back of the envelope calculations show that the decay parameter σ implicit in our results, lies somewhere in the range of 0.6–0.8.[24] This suggests that the impact of the EAC fell by about 50–60% with every hour of travel. Such a steep spatial decay is difficult to reconcile with the typical transport costs that prevail for long distance trade, as it would require ad-valorem transport cost of $\phi > 0.07$ for every hour of travel.[25] When we estimate hourly ad-valorem transport cost of long distance trade in the EAC using petrol prices, we attain $\phi = 0.005$. Even if we were to double or triple this figure to account for the fact that bulkier goods may be costlier to transport than petrol, we would still be far off from the high transport costs implied by our results.

Instead, the steep spatial decay is consistent with an effect that impinged more heavily on local cross-border trade than on formal long distance trade. Local cross-border trade takes place in much smaller quantities than formal trade, involving small or even non-motorized vehicles, such as bicycles and push carts. Due to large economies of scale in transporting goods, a relatively high spatial decay would therefore be expected, if the shock only affected local trade. A look into official trade data from UN Commtrade provides further evidence supporting this view. As illustrated in Fig. 2, the launch of the EAC did not leave a marked imprint on formal trade flows. While intra-EAC exports were increasing, trade with non-EAC countries did so too, so that the share of intra-EAC exports to total exports remained relatively stagnant at around 7% between 1997 and 2013. Moreover, anecdotal evidence suggest that despite the reduction in regional tariffs, formal trade continued to be impeded by the existence of large

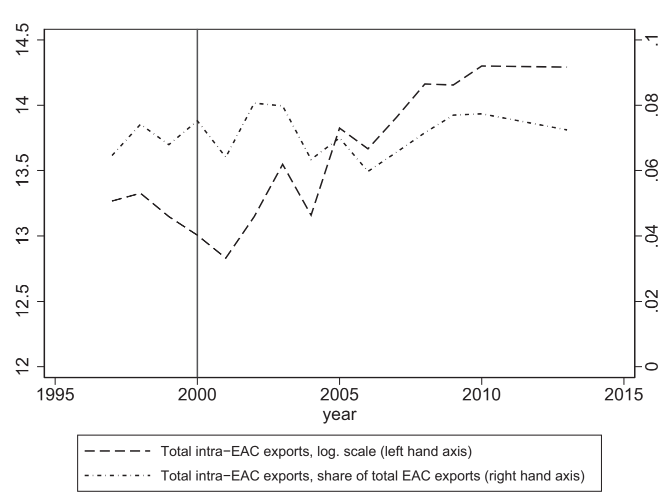

Fig. 2. Formal intra-EAC exports based on UN Comtrade data.

[24] Based on results in column 3, Table 4, we compare the average impact of the EAC establishment in the travel band nearest to the border (i.e. between 0 and 45 min from the border) with the average impact on cities in the third and fourth travel band (i.e. between 90-135 min and 135–180min from the border) and solve for a decay parameter that eliminates the difference.

[25] Notice that if we assume a trade elasticity in line with the literature of κ= 8.4 (Eaton and Kortum, 2002; Donaldson and Hornbeck, 2016; Caliendo and Parro, 2015) and a $\sigma > 0.6$, this requires ad-valorem transport cost $\phi > 0.07$.

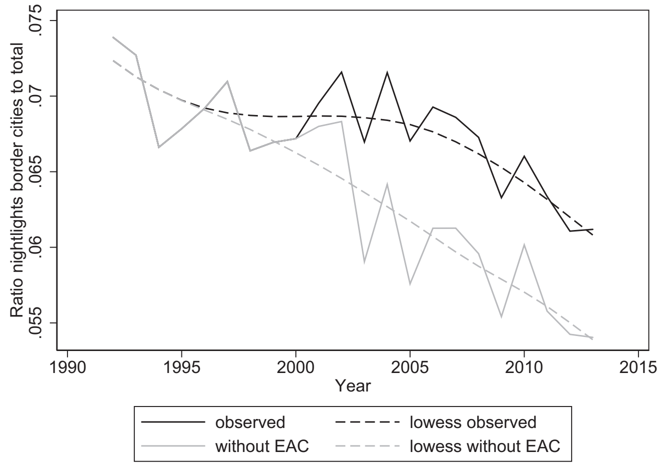

Fig. 3. Impact of the EAC on the share of nightlights emanating from border region cities.

Table 5
Placebo leads and treatment lags.

Variables	(1)	(2)
Border	−0.007	
	(0.005)	
Placebo leads		
$Border \times Yr_{99}$	−0.004	−0.004
	(0.022)	(0.022)
$Border \times Yr_{00}$	−0.014	−0.014
	(0.017)	(0.018)
Treatment lags		
$Border \times Yr_{01}$	0.032**	0.032**
	(0.014)	(0.015)
$Border \times Yr_{02}$	0.036**	0.036**
	(0.017)	(0.017)
$Border \times Yr_{03}$	0.012	0.012
	(0.020)	(0.020)
$Border \times Yr_{04}$	0.024	0.024
	(0.020)	(0.021)
$Border \times Yr_{05-09}$	−0.000	−0.000
	(0.007)	(0.007)
$Border \times Yr_{10-13}$	0.005	0.005
	(0.009)	(0.009)
Market access controls	YES	
Rainfall controls	YES	YES
Country-year FE	YES	YES
City FE	NO	YES
Observations	3,780	3,780

Notes: Data based on a panel of 180 cities in Kenya, Tanzania, and Uganda from 1992 to 2013. The dependent variable is the annual change in log nightlights. Yr_t are year dummies for each respective year *t*. All other variables specified in line with previous specifications. Robust standard errors adjusted for clustering at the city level in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% respectively.

non-tariff barriers after the establishment of the EAC (Calabrese and Eberhard-Ruiz, 2016; East African Business Council, 2007). Such non-tariff barriers are less likely to matter for local trade. This would explain why the EAC-FTA had an uneven impact on large-scale long distance and small-scale local trade. Therefore, our results suggests that local cross-border trade constitutes an important channel for how the effect of regional trade liberalisation is transmitted across space.

How large where these local effects and were they large enough to leave an imprint on the spatial distribution of economic activities across the region? We use results from column 5, Table 2, to establish this. The compounded difference in nightlights growth rates after the establishment of the EAC implies that by 2013 total nightlights in the EAC's border regions were 13% brighter than they would have been without the launch of the EAC. Based on the observed variation in border region cities' nightlights in 2013 this corresponds to 1.56 standard deviations or alternatively, when using the nightlights elasticity of GDP of 0.38, as estimated by Hodler and Raschky (2014) using subnational regions for Africa, this translates into a 5% higher GDP in border regions.[26]

These large local effects, however, did not necessarily imply a substantial change in the relative contribution of cities to economic activity in the EAC member countries. First, we note that cities in the border region account for a rather modest share of total economic activity. Second, the growth performance of cities in the periphery tended to fall below the one of the economic core 1992–2000. Third, the EAC provided a temporarily limited growth impulse over 4 years. Fig. 3 illustrates the overall effect. In 1992, cities near the EAC internal borders accounted for 7.4% of total nightlights. This share declined to 6.7% in 2000. We find that in the absence of the EAC this share would have decreased further to 5.4% by 2013, whereas the estimated growth effect of the EAC kept it at 6.1%.

5.3. Identification concerns and robustness checks

Anticipation effects. One pitfall in identifying the effect of the EAC may stem from anticipation effects that may have caused a response before the free trade agreement actually took effect. Thus, while we define the commencement of the EAC 2001 as the start of the treatment, expectations of the policy may have caused effects prior to 2001. For instance, an expectation of lower customs duties or prices could lead market participants to delay investment or consumption decisions in the years prior to the agreement. If anticipation effects existed, they should cause differential developments pre-treatment. We can test this by including placebo leads for the years 2000 and 1999. As Table 5 shows, we do not find evidence for a significant decline in nightlights growth rates among treatment cities in the years before the establishment of the EAC. Meanwhile, the strongly positive and significant treatment lags for the years 2001 and 2002 confirm our main result of a strong but temporary impact of the EAC on cities near the border.

Confounding effects. Nightlights are positively correlated with urbanisation (Small et al., 2005), regional GDP, both in levels and growth rates (Henderson et al., 2011; Hodler and Raschky, 2014), and wealth indices at the household level (Michalopoulos and Papaioannou, 2013). However, nightlights are also highly correlated with access to electricity. Because regional market integration agendas may include public good provision, one concern is that nightlights reflect infrastructure investments, rather than an expansion in local cross border trade. Installing new electricity capacity typically takes years from planning to construction. We therefore would not expect a big change in the first years of the EAC. We nevertheless test this more formally.

We use the WEPP to study *electricity production capacity* in border cities. We attribute the capacity of electricity plants to the urban agglomerations in which they are located. Transmission lines allow electricity to be moved.[27] Hence, the place of production may be detached from the place of consumption. Despite of this, we do find that power plants are often located within the boundaries of our

[26] Henderson et al. (2011) estimate a nightlights elasticity of 0.328 based on a global sample.

[27] Data on the extent of the national grid over time is not available.

Table 6
EAC, electricity production capacity, and nightlights.

	(1)	(2)	(3)	(4)
	Δ log Elec Prod Cap		Δ log Nightlights	
Δ Elec Prod Cap			0.013**	0.012*
			(0.007)	(0.007)
Border	−0.016		−0.010**	
	(0.014)		(0.004)	
Border × EAC_{FTA}	0.102	0.102	0.027***	0.027***
	(0.083)	(0.085)	(0.008)	(0.009)
Border × 2005 − 2013	YES	YES	YES	YES
Market access controls	YES		YES	
Rainfall controls	YES	YES	YES	YES
Country-year FE	YES	YES	YES	YES
City FE	NO	YES	NO	YES
Observations	3,780	3,780	3,780	3,780

Notes: Data based on a panel of 180 cities in Kenya, Tanzania, and Uganda from 1992 to 2013. The dependent variable in columns 1–2 is the annual change in log electricity production capacity and in columns 3–4 it is the annual change in log nightlights. All other variables specified in line with previous specifications. Robust standard errors adjusted for clustering at the city level in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% respectively.

urban agglomerations. In 2000, 79% of power plants and 71% of the electricity production capacity were located within the boundaries of our 180 urban agglomerations. Over time, electricity production capacity becomes even more concentrated in cities, e.g. in 2013, 80% of the electricity production capacity was located within the boundaries. As one would expect, these are mostly diesel powered plants, whereas water powered plants (dams) are located away from cities.[28]

We first re-estimate Eq. (1) but replace the dependent variable using log electricity production capacity instead of nightlights.[29] Results in Table 6 show that electricity production capacity increased in border cities 2000–04, but not significantly so. Estimates are stable, independent of whether we include controls (column 1) or use city fixed effects (column 2). In column 3–4, we run a mediation analysis, to see whether the increase in nightlights in border cities can be partly attributed to an expansion in the electricity production capacity. If so, the estimated FTA effect would decrease. While we find that electricity production capacity is significantly positively correlated with nightlights, the FTA effect on nightlights in border cities 2000–04 remains unchanged. Overall, while we cannot account for transmission lines, we interpret this result as suggestive evidence that the characteristical spatial pattern in nightlights that we find is unlikely to be driven by an asymmetric extension of electricity infrastructure in border regions.

Apart of an increase in infrastructure investments, the FTA may have also led to an increase in trade related traffic and congestion. Border crossings would be particularly affected. If so, this could also cause an increase in nightlights. In Web Appendix Table A3 we exclude the seven cities with border crossings from our estimation. Results hold.

Choice of control group. We match each of the 21 treatment cities with one control city so that both are located within the same country, and share similar characteristics in terms of their average annual rainfall levels, 1992 nightlights, population, domestic market access, and distance to the primate city.[30] Web Appendix Table A3 reports the results when we re-estimate our baseline Eq. (2) using matched cities. Matching strongly reduces the number of observations. Yet, the overall growth impact on cities near the border is only marginally lower than in Table 2, column 5 and remains significant at the 5% level. This is further evidence that differences in city characteristics are not driving our results and that cities near the border experienced a strong but temporary increase in local economic activity due to their better access to the EAC market.

Specification concerns. We investigate the sensitivity of our results with respect to our choice of specification using growth in nightlights. To this end we repeat our baseline specification but use nightlight in levels rather than changes, and control for different trends between treatment and control cities. However, we are aware of the fact that the gradual impact of the EAC implies that the inclusion of a trend would attenuate our results, as demonstrated by Meer and West (2015). Hence, we estimate the impact of the EAC using the levels of log nightlights every fourth year between 1992 and 2004 as the dependent variable (i.e. 1992, 1996, 2000, 2004, 2008, 2012). This allows us to abstract form the gradualism in the impact observed between 2001 and 2004. The results are reported in Table A5 and are in line with our main specification. The trend variable is negative and highly significant, suggesting that before the EAC the level of nightlights in treatment cities shrunk by 5.4% every four years relative control cities. In the first four years after the establishment of the EAC, treatment cities then experienced a 13.0% increase in nightlights relative to the pre-EAC trend. Consequently the level of nightlights in treatment grew by around 6.8% relative to control cities over the first four years of the EAC. This implies that, on average, cities in border regions outgrew cities in interior regions by just under 2% annually, which is in line with results presented in Table 2.

We also account for the possibility of spatial auto-correlation, both over time and across cities, using Conley standard errors as proposed in Conley (1999). Table A6 in the Web Appendix reports regression results for our baseline specification using Conley standard errors with different distance thresholds. Standard errors are somewhat higher, yet our inferences remain unchanged.

Cross-country heterogeneity. Finally, we check for heterogeneity in responses across countries re-estimating Eq. (2) for each country sep-

[28] Web Appendix Fig. B1 shows the development of the electricity production capacity by country 1992–2013. Comparing this with official statistics on capacity in selected years reveals a fairly good fit. 114 of the 180 cities had no power plant over the full period. In 2000, cities located 90 min from a border crossing accounted for 17%, 1% and 0% of electricity production capacity in Kenya, Tanzania, and Uganda. In 2013, the percentages have changed to 10%, 2% and 7% respectively.

[29] Several cities display zero electricity production capacity. In order to use all observations, we added 0.015 electricity production capacity of all agglomerations before taking the log. The value of 0.015 represents the minimum nonzero electricity production capacity observed in the data.

[30] Matching is performed by applying the Mahalanobis metric, which minimizes the squared difference in these characteristics between treated and paired control city.

arately. Results are reported in Web Appendix 2 Table A7. We find that the treatment effect is largest for Uganda, followed by Tanzania and then Kenya. However, when using the border cities' own pre-treatment growth rates as reference, the effects are very similar across the countries.

6. Firms and the EAC

In this section we show that our findings are corroborated when using firm level data from the 2002 Ugandan Business Register (UBR). The UBR enumerated all formal and informal firms with a fixed location across Uganda, recording firms' geo-location and year of establishment, which allows us examine whether firm formation followed a similar spatio-temporal pattern as our nightlights measure of economic activity. We also confirm that effects were present across a wide range of sectors. This alleviates concerns that the expansion in nightlights in border regions comes from congestion, such as longer waiting times at border crossings, and a narrow expansion in the transport and hospitality sectors. We replicate the identification strategy of previous sections.

UBR is a cross-section of firms. To retrieve a temporal dimension we make use of the firms' year of establishment. We estimate the following linear probability model:

$$Prob(Border_f = 1) = \lambda_0 + \lambda_1 EAC_f + \mu_f \tag{4}$$

where $Border_f$ is a dummy variable equal to one if firm f was established less than 90 min of travel from a border post to Kenya and Tanzania, and EAC_f is a dummy variable equal to one if firm f was formed after the establishment of the EAC. We are primarily interested in $\lambda_1 > 0$ or in other words, whether at the time of the survey in year 2002 we observe a higher proportion of border firms established after the EAC than before the EAC (which is given by λ_0). Note that $\lambda_1 > 0$ can stem from both, increased firm creation and survival in border regions after the EAC, both of which is consistent with increased market size. However, λ_1 may also be larger than 0, if there is more entry and exit of firms in the periphery in general, e.g. because firm structures are generally different in that they are smaller and less endowed with physical and human capital.[31] We therefore expand specification 4 and include dummies for the years 1998 and 1999, using the year 2000 as the base year. If these dummies are not significant, the proportion of border to non-border region firms remained relatively constant before the EAC, indicating that the year 2001 indeed marks a discontinuous change. We then repeat the estimation for different sectors.

Results are shown in Table 7. Column 1 confirms an increase in firm formation and/or survival in border relative to non-border regions following the establishment of the EAC. Had the proportion of border to non-border firms remained the same as in pre-EAC years, there would have been 29% fewer firms in the border region. Moreover, when including pre-treatment leads in column 2 we do not observe a particular trend that would suggest lower survival probabilities in border relative to non-border regions. There is a comparably small, yet significant, increase in the relative probability of firm formation in border regions for the year 1999 compared to the base year (i.e. 2000), which could suggest that something else drove up firm formation near the border in that year. The sector specific regressions in columns 1–9 show that this result is not consistent across sectors but driven by the retail sector. We therefore do not attach much weight to this result. By contrast, the EAC effect is much larger and consistent across all sectors. Moreover, the effect is particularly large for sectors one would expect to gain from increased localized trade, such as manufacturing, wholesale and

Table 7
Firm formation in EAC border regions.

	(1) All	(2) All	(3) Manufacturing	(4) Wholesale	(5) Retail	(6) Hospitality	(7) Social Services	(8) HH Services	(9) Business Services
EAC	0.026***	0.029***	0.041**	0.045***	0.030***	0.022***	0.022	0.026***	0.050**
	(0.003)	(0.003)	(0.019)	(0.016)	(0.005)	(0.008)	(0.021)	(0.009)	(0.022)
Est. 1999		0.010**	−0.014	0.019	0.010*	0.015	0.006	0.015	0.010
		(0.004)	(0.021)	(0.017)	(0.005)	(0.011)	(0.023)	(0.012)	(0.024)
Est. 1998		−0.001	−0.030	−0.006	0.002	−0.002	−0.011	−0.016	0.031
		(0.004)	(0.021)	(0.018)	(0.006)	(0.012)	(0.023)	(0.012)	(0.027)
Constant	0.110***	0.107***	0.142***	0.078***	0.119***	0.087***	0.113***	0.068***	0.084***
	(0.002)	(0.003)	(0.014)	(0.010)	(0.003)	(0.006)	(0.015)	(0.007)	(0.015)
Observations	54,548	54,548	2,362	2,249	33,480	7,328	1,634	4,842	1,205

Notes: This table estimates the probability of firm formation in border regions between 1998 and 2001. Data based on 2002 Uganda Business Register. The dependent variable is a dummy variable indicating a firm located within 90 min travel time of an internal EAC border between Uganda and Kenya, and between Uganda and Tanzania. The explanatory variables are dummy variables for the year of establishment. In column 1 the omitted category represents firms established in before the EAC (1998–2000). In columns 2–9, the omitted variable represents firms established in 2000. Column 1 and 2 uses the complete sample of firms, whereas columns 3–9 limit the sample to firms of corresponding ISIC4 sectors, omitting the residual category "Other" from the table. Robust standard errors in parentheses, where ***, **, * indicates significance at the 1%, 5% and 10% respectively.

[31] The share of firms with zero employees is indeed larger in the border region, but this difference remains constant throughout ageing and selection of firms 1998–2000. See Web Appendix 2 Table A8.

Table 8
The EAC and firm formation across space.

	(1)
$Border_{0-45}$	0.090***
	(0.010)
$Border_{45-90}$	0.062***
	(0.008)
$Border_{90-135}$	0.046***
	(0.006)
$Border_{135-180}$	0.035***
	(0.007)
Constant	0.393***
	(0.002)
Observations	54,548

Notes: This table estimates the probability of firm formation in 2001. Data based on 2002 Uganda Business Register. The dependent variable is a dummy variable indicating whether a firm was established in 2001. The explanatory variables are dummy variables indicating whether a firm falls into different distance bands from an internal EAC border between Uganda and Kenya, and between Uganda and Tanzania. The omitted category represents firms located more than 180 of any EAC border. Robust standard errors in parentheses, where ***, **, * indicates significance at the 1%, 5% and 10% respectively.

retail. The non-tradable sector (e.g. hospitality and household services) also experienced an increase in the number of firms but this effect is smaller.

We next test, whether the firm level data follows a similar spatial pattern as the one in nightlights. To this end, we rely on the same distance bands used previously, namely a firm's distance to the border of 0–45min ($Border_{0-45}$), 45–90min ($Border_{45-90}$), 90–135min ($Border_{90-135}$), and 135–180min ($Border_{135-180}$). We stipulate the following linear probability model:

$$Prob(EAC_f = 1) = \rho_0 + \rho_1 Border_{0-45,f} + \rho_2 Border_{45-90,f} + \rho_3 Border_{90-135,f} + \rho_4 Border_{135-180,f} + \mu \qquad (5)$$

Eq. (5) tests whether the probability that a firm was established in 2001 ($Prob(EAC_f = 1)$) varies by distance to the border. ρ_0 measures the probability that a firm was established in 2001 for the base category (i.e. firms located more than 180 travel minutes from an EAC border) and $\rho_1 - \rho_4$ measure the incremental change in the probability as one moves closer to the border. In line with our previous results we expect $\rho_1 > \rho_2 > \rho_3 > \rho_4$.

Results are shown in Table 8. 2002 surveyed firms located more than 180min from the border had a probability of having been established in 2001 of 39%. This probability increased monotonically the closer firms were located to the EAC border. The spatial pattern suggested by these results is remarkably similar to the one found when using nightlights.

Fig. 4 plots the evolution of impact coefficients of nightlights and firms by distance band. Both lines decline broadly in parallel to each other with increasing distance to the border. We interpret this result as evidence that the increase in nightlight emissions observed near the border following the establishment of the EAC did indeed occur on account of an increase in economic activity on the ground. Moreover, these results are consistent with an increase in local trade as the main channel for the asymmetric response to the establishment of the EAC. We interpret this as strong suggestive evidence that the establishment of the EAC brought about an increase of firm formation in border regions.

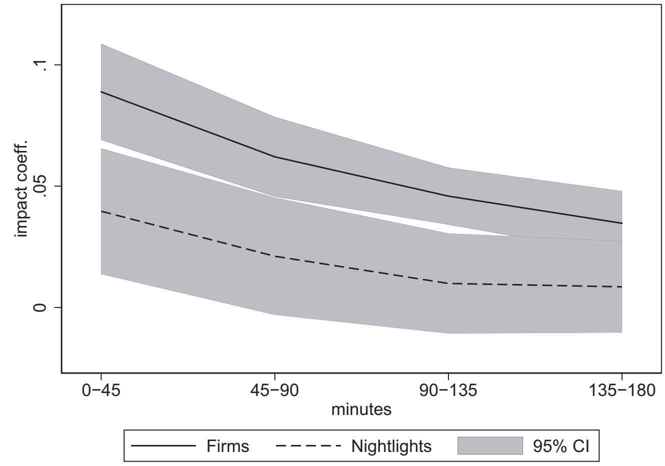

Fig. 4. The spatial impact of the EAC on firms vs. nighlights.

7. Summary

Across sub-Saharan Africa many countries have embarked on extensive regional trade agreements and liberalisation agendas. Yet the extent to which the opening of regional borders has distributional consequences over space within countries remains little understood. In this paper we address this gap by investigating the changes in the spatial concentration of economic activities after the EAC between Kenya, Tanzania, and Uganda was launched in 2001.

Measuring economic activity using satellite imagery of lights emanating from Earth at night for a panel of 180 cities, we show that after the establishment of the regional block cities near the EAC's internal border grew more strongly than cities further inland. Consistent with the occurrence of a positive market access shock due to a one-off reduction in cross-border trade costs, the growth effect lasts for about four years. In addition, we demonstrate that the effect is spatially concentrated on cities located less than 90 min from the border. We show that high transport costs, which determine the strength of the shock across cities, are insufficient to explain this spatial pattern. Rather, our results are consistent with an asymmetric impact on two different trade modalities which co-exist in many parts of Sub-Saharan Africa, local small-scale trade and regional large-scale trade, with a strong reduction in trade costs for the former but not for the latter. The resulting local effect on cities near the border is large, equivalent to 5% of GDP between 2001 and 2013. However, the aggregate effect is small and insufficient to have a lasting impact on cities' relative contribution to total economic activity in the region. We therefore conclude that in terms of city growth the EAC's establishment had strong short-run local effects but limited regional effects.

Appendix A and B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jdeveco.2019.06.005.

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